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1. INTRODUCTION

1.1 OVERVIEW

Historical releases of certain classes of organic and inorganic chemicals into waterbodies have left a legacy of aquatic sediment enriched with these contaminants. In some sediments these contaminants have accumulated to levels that may pose an unacceptable human health and ecological risk. Of particular concern is the historical release to waterbodies of compounds known as polychlorinated biphenyls (PCBs), given that they are toxic, persistent, and bioaccumulate in the food chain.

PCBs historically were released to the Housatonic River (see Figure 1-1) from the General Electric (GE) facility in Pittsfield, MA. Over a period of decades, these compounds have accumulated in the river's bed sediment and impoundments in Massachusetts and Connecticut. High-flow events have transported PCB-laden sediment onto the adjacent floodplain. Data collected from 1982 to the present have documented the magnitude and extent of the PCB contamination of the sediments and floodplain soils adjacent to the Housatonic River downstream of the GE facility. The extent of the PCB contamination was estimated in previous investigations to fall within the 10-year floodplain of the Housatonic River.

In addition, PCBs in fish tissue have accumulated to levels that pose a risk to human health (EPA, 1998a). A recent U.S. Geological Survey (USGS) report (Garabedian et al., 1998) notes that PCB concentrations in streambed sediments and fish tissue in the Housatonic are some of the highest of all their National Water-Quality Assessment Program (NAWQA) study sites across the country. In 1982, the Massachusetts Department of Environmental Protection (MADEP) issued a consumption advisory for fish in the Housatonic River from Dalton, MA, to the Connecticut border. Previously Connecticut had issued a fish consumption advisory for sections of the Housatonic River in Connecticut as a result of PCB contamination. In 1999, MADEP issued a consumption advisory for ducks collected from the river from Pittsfield to Rising Pond in Great Barrington, MA. Concerns expressed by local residents regarding possible health effects resulting from exposure to PCB contamination are being investigated by the Massachusetts Department of Public Health.

1 In September 1998, after years of scientific investigations and regulatory actions, a
2 comprehensive agreement was reached between GE and various governmental entities, including
3 EPA, MADEP, the U.S. Department of Justice (DOJ), Connecticut Department of Environmental
4 Protection, and the City of Pittsfield. The agreement provides for the investigation and cleanup
5 of the Housatonic River and associated areas. The agreement has been documented in a Consent
6 Decree between all parties that was lodged with the Federal Court in October 1999. Under the
7 terms of the Consent Decree, EPA is conducting the human health and ecological risk
8 assessments, as well as the detailed modeling study of PCB transport and fate for the Housatonic
9 River below the confluence of the East and West Branches (“Rest of River”) and the surrounding
10 watershed.

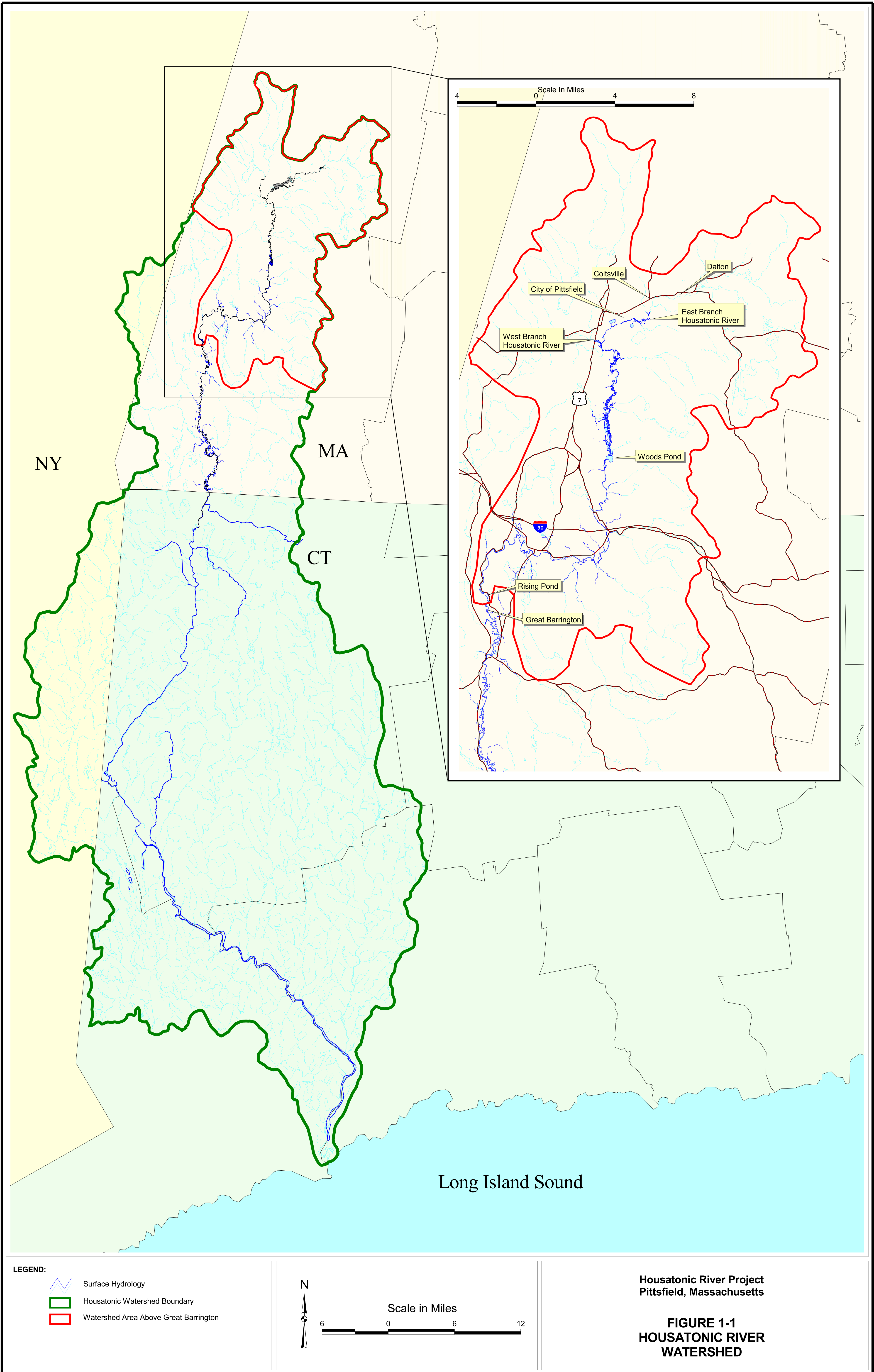
11 The Consent Decree also includes specific language that requires the risk assessments and
12 components of the modeling studies to be submitted for formal Peer Review to help guide the
13 effort and ensure consistency with EPA policy and guidance. This report, the proposed
14 Modeling Framework Design, is the first component of the modeling study to be submitted for
15 Peer Review.

16 **1.2 PURPOSE AND OBJECTIVES OF THE HOUSATONIC RIVER MODELING** 17 **STUDY**

18 Evaluation of the risks posed to human health and the environment from contaminated sediments
19 often requires the application of coupled watershed/hydrodynamic/water quality models and
20 contaminant fate and bioaccumulation models to address the full range of migration pathways of
21 chemicals released to the environment. The use of a fully integrated modeling framework is
22 needed to produce a scientifically defensible application of models to support regulatory
23 decisionmaking.

24 The proposed modeling study design was developed to (1) represent the full range of physical,
25 chemical, and biological processes of concern for PCB fate, transport, and bioaccumulation in
26 the Housatonic River watershed, and (2) address each of the following site-specific study
27 objectives:

- 28 ▪ Quantify future spatial and temporal distribution of PCBs (both dissolved and
29 particulate forms) within the water column and bed sediment.



- Quantify the historical and relative contributions of various sources of PCBs on ambient water quality and bed sediment.
- Quantify the historical and relevant contribution of various PCB sources to bioaccumulation in targeted species.
- Estimate the time required for PCB-laden sediment to be effectively sequestered by the deposition of “clean” sediment (i.e., natural recovery).
- Estimate the time required for PCB concentrations in fish tissue to be reduced to levels that no longer pose either a human health or ecological risk based on various remediation and restoration scenarios, including allowing for natural recovery.
- Quantify the relative risk(s) of extreme storm event(s) contributing to the resuspension of sequestered sediment and the redistribution of PCB-laden sediment within the area of study.

1.3 BROADER MODELING STUDY OBJECTIVES

In addition to meeting the site-specific objectives, the modeling study must be designed to achieve even more basic objectives inherent to the successful execution of any modeling effort. These broader objectives are discussed below.

1.3.1 Achieving Mass Balance

The fundamental test of any complex modeling study is to demonstrate that a “mass balance” has been achieved for each of the key constituents being modeled. For this investigation, the primary constituents being modeled are water, solids, and PCBs. The principle behind achieving a mass balance is to ensure that all inputs, outputs, and internal source/sink terms have been properly accounted for. This requires an accurate representation of the relevant physical, chemical, biological, and geologic processes within the models that will be used for this investigation.

1.3.1.1 Water Mass Balance

The modeling study must achieve an overall water mass balance that reproduces the historical distribution of observed flows within the Housatonic River. This is an important component of the analysis given the role hydrodynamics play in the physical transport of solids and PCBs. To impose an appropriate external forcing function on the hydrodynamic model, a calibrated and

1 validated hydrologic model must be developed. The hydrologic model must account for
2 tributary flows into the region covered by the hydrodynamic model as well as movement of
3 water through the main river channel at the boundaries of the hydrodynamic model.

4 The hydrologic model must establish these external boundary conditions to the hydrodynamic
5 model under both historical conditions and projected future conditions. The hydrodynamic
6 model, in turn, uses the external boundary conditions to simulate the distribution of flows within
7 the system and resulting internal forces acting on the sediment bed. To represent future
8 conditions, an implicit assumption is made that historical conditions (e.g., spatial and temporal
9 distribution of flow and solids) are representative of future conditions. A validated hydrologic
10 model provides the technical basis for developing probability-based, future boundary conditions
11 to the hydrodynamic model.

12 **1.3.1.2 Solids Mass Balance**

13 Because of the preference for PCBs to adsorb to sediment, achieving mass balance of solids is
14 very important to the success of the model in accurately representing the conditions in the system
15 being modeled. A change in the solids mass balance will ultimately affect the overall PCB mass
16 balance. The purpose of the solids mass balance is to ensure that both short- and long-term
17 transport of solids can be reproduced within the model validation process.

18 **1.3.1.3 PCB Mass Balance**

19 The PCB mass balance is the primary objective of this study. Numerous complex fate and
20 transport processes influence the distribution of PCBs within the river and the floodplain. The
21 PCB mass balance will define what processes are controlling the ultimate distribution and fate of
22 PCBs within the study area.

23 Definition of the PCB mass balance requires accurate source characterization and representation
24 of the distribution of PCBs in the conceptual model for the site.

1.3.2 Ability to Provide an Estimation of Future Conditions

The primary objective that will be pursued after achieving acceptable mass balance in the models is the ability to answer questions regarding the future spatial and temporal distribution of PCBs in the various media under different potential remedial scenarios.

It should be emphasized that the ability of any model to accurately answer questions and/or predict future conditions that span a period of decades must be carefully considered. Consequently, in the final analysis a “weight of evidence” approach will be taken, including all available information and tools in addition to the model output.

1.3.3 Evaluation of Uncertainty

Any modeling study presumes that the fundamental questions to be answered with the assistance of models are known a priori. This is an appropriate assumption given that a scientifically valid modeling framework cannot be defined otherwise. Since the modeling framework provides the mathematical representation of the science underlying the study, it is necessary that the models applied within the framework are appropriate for the purpose of answering these questions. In other words, the models must incorporate algorithms that are credible representations of real-world processes.

Because natural systems inherently have complex, random, and nonlinear processes that cannot be accounted for in any model, it should be clearly emphasized that any model formulation strives for a compromise between physical reality and practicality of use. This is particularly true of numerous physical, chemical, and biological processes occurring within this system. In many cases, no empirical or predictive methods exist that would allow a model to reproduce the consequences of these processes.

However, one cannot simply dismiss these processes as only introducing marginal or second-order error terms into the solids and PCB mass balance equations because no empirical relationships exist to predict their distribution and occurrence. Therefore, as stated above, model output will be augmented using a “weight of evidence” approach with other nondeterministic methods to reduce the degree of uncertainty associated with these processes. In addition, effort

- 1 will be made to identify other areas of uncertainty such as changes in channel dimensions,
- 2 entrainment of slumped bank sediments, dissolution and transport of dense nonaqueous phase
- 3 liquids (DNAPL), population fluctuations, and sporadic macrophyte die-back.